Water retention capacity of biochar blended soils

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ABSTRACT

Biochar is a fine-grained and porous form of charcoal that is specifically made for use as a soil amendment and soil conditioner. Biochar helps the soil as soil conditioner, soil amendment and alters pH of soil. These positive benefits help plants for better growth and disease resistance. It is now the subject of academic research which will establish the potential to support reduced fertilizer use, reduced irrigation and increased yields. Present study focused on impact of biochar amount on water retention capacity of biochar blended soil. Biochar was prepared through pyrolysis process. Locally available saw dust and rice husk were collected from local market of Udupi of Karnataka State, India. Various combinations of biochar blended soil and water levels (continuous mode) were used in the study and identified the suitable combination of biochar blended soils to reduce the water evaporation rate/improve the water retention rate. The rate of water evaporation was continuously reduced with time for once addition of water and termed as batch operation of water while the rate of water evaporation was more with time for regular addition of water at intermittent times is termed as continuous operation. Increase in biochar amount will increase the retention of water. Addition of biochar to the soil may retain the water more and reaches to saturation of the evaporation of water. Addition of more biochar will be helpful to retain more amount of water in soil or less evaporation rate.

KEY WORDS: Biochar, Pyrolysis, water evaporation rate, biochar blended soil.

1. INTRODUCTION

Biochar is a most commonly produced through energy conversion process known as pyrolysis of organic materials such as crop residues, wood chips, manure and municipal waste. The solid product from this process is called Biochar. Biochar is fine-grained and porous form of charcoal that is specifically made to use as a soil improver. Added to soil, it can help to boost soil health, with positive benefits to plant growth and disease resistance. The concentration of microbial life within biochar also supports greater moisture retention (Lehmann, 2009; Lehmann, 2006). Other products of pyrolysis may include synthetic or synthesis gas and pyrolysis liquor (Gaunt, 2008).

Advantages of biochar addition to soil includes:

Soil biota: The porous nature of biochar's provides a safe habitat for many microorganisms such asmycorrhizal fungi and actinomycetes bacteria (abundant in worm casts). Biochar helps to grow the microbial populations for plant growth at a higher level, while simultaneously reducing the rate at which soil gives off greenhouse gases(Lehmann, 2009; Lehmann, 2006).

Mineral retention: Biochar has a weak cation exchange capacity that helps in retaining the dissolved nutrient minerals from being leached from the soil by rain or irrigation. This leads to reductions in the usage of fertility inputs with consequent cost savings (Lehmann, 2006; Lehmann, 2009).

Water retention: Biochar's porosity traps water and therefore reduces water usage. Trials have shown this can save as much as 50% on irrigation costs. The concentration of microbial life within biochar also supports greater moisture retention (Lehmann, 2009; Lehmann, 2006).

Soil structure: A soil that has a high population of mycorrhizal fungi will benefit from their production of glomalin, a substance which assists soil particle agglomeration, giving it structure and reducing the escape of stored soil carbon. By encouraging fungal growth, biochar indirectly supports improved soil structure. While many articles report on carbon sequestration potential and nutrient trapping, a few studies on the effect of biochar on water holding capacity. A study (Novak, 2009) on loamy soils shown an increase in the water holding capacity for 2% mixtures of biochar made from various switchgrass feedstocks. The ability of biochar to increase water holding capacity could have profound effects on areas prone to drought (Karhu, 2011).Terrapreta of Amezon soils shown that biochar can remain stable in soil for hundreds to thousands of years (www.biochar.org). Preliminary results on biochar use as soil amendment have been documented in factsheets and brochures, published by the Department of Agriculture, Fisheries and Forestry, under the Climate Change Research Program. A number of other biochar projects are underway throughout Australia and are listed on the Australia and New Zealand Biochar Researchers Network. Through these initiatives, the knowledge gaps are likely to diminish. Once knowledge of the biological processes involved is enhanced, a coordinated government approach will be needed to develop standards and regulations for the industry to safeguard against contamination of agricultural soils, and to integrate this technology into an accredited emissions trading scheme. Present work is focused on drying or evaporation rate of water from biochar blended soils. The summarized report on current state of biochar knowledge was given by Sohi et al. (Sohi, 2009) and concluded that soil water holding capacity was an area of significance that was lacking in research.

2. MATERIALS AND METHODS

Biochar was prepared through pyrolysis process. Locally available saw dust and rice husk were collected from local market of Udupi of Karnataka State, India. A schematic experimental setup was shown in Figure 1. As can be seen from Figure 1, two metal barrels were used to prepare the biochar. The smaller barrel was filled with saw dust or rice husk and kept upside down method such that bottom part of the smaller barrel will come into upper side.

Figure.1.Experimental setup for preparation of biochar

A small opening on top of the small barrel provided for escape of the gases during the process. The hollow space between these barrels was completely filled with fire wood. This firewood was used to provide the heat once the fire starts. The rice husk and saw dust would undergo the pyrolysis process. The process continues 2 hours and stop the fire with the help of mud. The detailed procedure was explained else-where (Nishanth, 2013; Gururaj, 2014; Gerlad, 2013). The prepared biochar was analyzed after cooling to room temperature. The biochar was grounded to smaller size and packed in polyethylene cover till further use.

Methodology: Soil from Udupi of Karnataka, India was collected (50 kg's) from fields. Ten plastic troughs with following dimension were (50 cm x 30 cm) used to conduct the water retention test. One trough was used as blank and others were used for experiment. Table 1 show the various combinations of soil blended biochar and water amount used for the water retention test.

Table.1.Combinations of biochar blended soils with water matrix

Tray no	Wt of tray (kg)	Wt of soil (kg)	Wt of biochar (kg)	Wt of water (kg)
1A	0.22	3	0.09	0.45
1B	0.22	3	0.18	0.45
1C	0.22	3	0.27	0.45
2A	0.22	3	0.09	0.65
2B	0.22	3	0.18	0.65
2C	0.22	3	0.27	0.65
3A	0.22	3	0.09	0.85
3B	0.22	3	0.18	0.85
3C	0.22	3	0.27	0.85

Tray 1A means 3 kg of soil, 0.09 kg of biochar (0.03 kg/kg of soil basis) (Jagga, 2014). An amount of 0.45 kg of water added daily in the morning to the above trough. The water was sprinkled on biochar blended soil such that the water distributed uniformly through the trough. Similar amount of water was added on day 2 morning 9 AM. This was continued till 5th day morning 9 AM. Tests were conducted during day time (8 hrs period) from 9 AM to 5 PM and collected the total weight of the trough at 9 AM and 5 PM. This trough was kept open on terrace such that it exposed to solar light. Similarly other 9 troughs also filled with biochar blended soil with various combinations as shown in Table 1.The experiments were conducted 4 days. During night the troughs were closed with plastic cover to prevent night evaporation. Total weight was measured at morning 9 AM before addition of water and after adding water and evening 5 PM. Use of water 0.45 kg was termed as lower water addition, 0.65 kg was termed as intermediate and 0.85 was termed as higher water addition.

3. RESULTS AND DISCUSSIONS

The data obtained from the experiments were transformed into water evaporation rate with time (this was calculated based on 8 hours on day 1 and another 8 hrs on day 2, so 1st two days the time of solar exposure was 16 hours, 3rd day completion will be 24 hours solar exposure time and at the end of the experiment of 4th day will be 32 hours). Figure 2 show the variation of rate of water evaporation with time (cumulative time) for once water addition to the biochar blended soil, this one will be called as batch operation. The present experimental results will be termed as continuous mode of water addition to the biochar blended soil. In case of batch operation as the time or days passing the water evaporation rate decreased, the reason might be water evaporation rate is proportional to water content in biochar blended soil. Day 1, beginning of the experiment was more evaporation and finally the last experimental day i.e day 5 less evaporation rate (Yu, 2013). The rate of water evaporation was given below; the same was used for continuous mode also. dX/dt = amount of water evaporated/amount of biochar blended soil x time. The water evaporation rate of tray 1 to 3 for different biochar blended soils were shown in figure 3,4 and 5 (filled circle tray 1A, filled triangle is tray 1B and filled rectangle is tray 3A, same notation was followed in figures 6 to 8, Table 1 show the detailed information on loading of biochar and water loading). From figure 3 the rate of water evaporation was increased with time or number of days. Water evaporation rate was strongly depends on water available in the soil and same was observed from figure 2. Day1, available water within the soil was less so the water evaporation rate was less and on second due to addition of fresh water net available water in biochar blended soil was more, so the water evaporation increased and reached to a saturated value. Further increase in water with soil does not change the water evaporation. From these graphs one can concluded that the water evaporation will increase with availability of water in the soil but evaporation reached a maximum or saturated amount. This was the indirect information on water retention in the biochar blended soils. Similar observations can be made from figure 4 and 5 for various biochar loading soils.

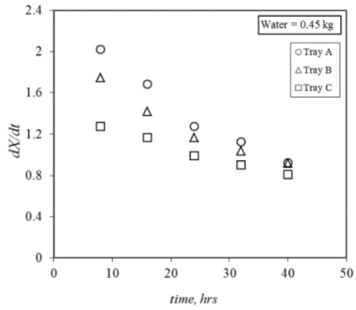

Figure.2.Comparision of evaporation rate for constant water

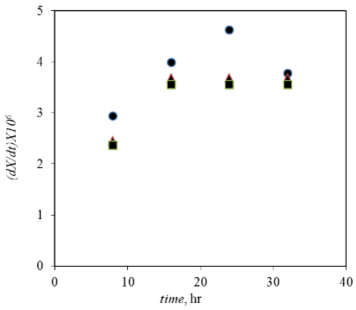

Figure.3.Variation of evaporation rate with biochar loading

Effect of water loading: Figure 6 show the effect of amount of water added on water evaporation rate for amount of biochar present in soil (0.09 kg). Tray 3 had shown highest water evaporation rate than tray 2 and 3. Tray 2 shown intermediate evaporation while tray 1 had less evaporation rate. Tray 3 contains more amount of water than tray 2 and 1. It is very clear that, increase in amount of water increases the evaporation rate (NIshanth, 2013). This is true for all the days. Similar observations can be made from Figures 7 and 8 for intermediate and higher biochar addition to soils.

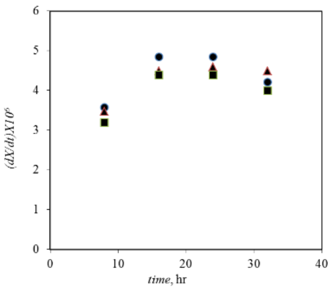

Figure.4.Variation of water evaporation rate biochar loading

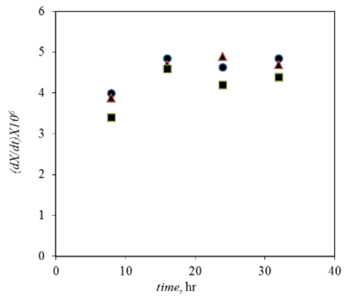

Figure.5. Variation of water evaporation rate biochar loading

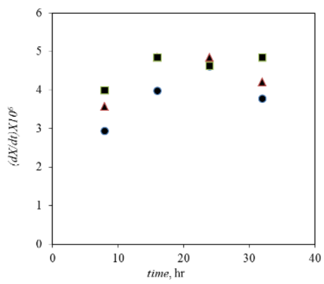

Figure.6.Variation of water evaporation rate with water loading

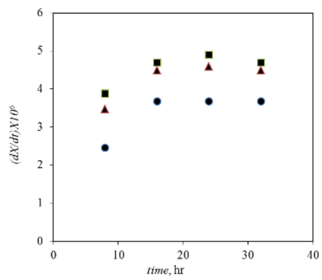

Figure.7.Variation of water evaporation rate with various water loading

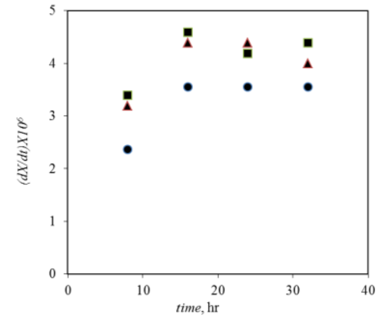

Figure.8.Variation of water evaporation rate with various water loading

4. CONCLUSIONS

The following conclusions can be drawn from the present study

1. Addition of biochar to the soil may retain the water more and evaporation rate reaches to saturation with time.
2. Addition of more biochar will be helpful to retian more amount water in soil or less evaporation rate.
3. This retention may lead to less irrogation cost in agriculture.

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